OPTICAL HEAD MOUNTED DISPLAY USING AUGMENTED REALITY

Rohit Kumar Pal *

Nitish Kumar Sharma *

ABSTRACT

Recently, because of the rapid development of mobile devices, augmented reality has extended from personal computers to wearable mobile devices. They are getting popular as a platform for Augmented Reality (AR) based Optical Head-Mounted Displays such as Google glass. The highly interactive nature of OHMD with its user has given rise to various wearable mobile devices, ranging from mere interaction to marketing, games, navigation, and so on. OHMD is mainly available whenever people require an informational support for a focused task.

The combination of HMD and collaborative Augmented Reality into a single system makes the power of computer enhanced interaction and communication in the real world accessible anytime and everywhere.

The objectives of the proposed work include main aspects of Augmented Reality based Head-Mounted Displays for development of wearable computers. It describes the main fields in which OHMDs are developed using AR systems, current ongoing works in different firms and there future expectations from HMDs.

KEYWORDS

Augmented Reality, Virtual Reality, Scientific Visualization, Optical Head Mounted Displays, Wearable Computing

*Students, School of Computing Science and Engineering, Galgotias University

I. INTRODUCTION

Augmented Reality (AR) is a new technology that involves the overlay of computer graphics on the real world. One of the best overviews of the technology is, that it defines the field, describes many problems and summarizes the developments up to the point. HMDs are one of the many devices in which Augmented Reality has served its importance. HMD may be thought as the ViewMaster of virtual environment (VE), where the simple stereoscopic slides have been replaced by miniature electronic displays and the displays and optics are headband or helmet mounted.

HMD designs may be broadly classified into two types as:

Immersive- Immersive optics refers to design that blocks the direct real world view.

See-through- See-through optics refer to design that allow augmentation of synthetic images onto the real world [1]

The first Head Mounted Display, "The Sword of Damocles" was created by Ivan Edward Sutherland in 1968[2]. Though, as first HMD, it has its limitations like its weight and head tracking issues, it was a revolutionary invention. The acronym HMD has been used since to also refer to head mounted displays in military applications, where display is attached to military helmet[3][4]. After that many scientist have been working on Augmented & virtual reality and HMD and taken it to a whole new level. Head Mounted Displays has evolved into Head wearable displays. Optical see through Head Mounted Display (OSTHMD) is the most attentive field of developers.

This paper starts with the general idea of concepts used in augmented reality based See-through HMD. The main focus then shifts to the technologies used, various components of HMDs and key aspects of the user interface. We then briefly review existing Optical HMDs, their functionalities and finally the future scopes of HMDs.

II. GENERAL CONCEPTS

Optical head-mounted display is a display that can be worn by user and it has the capability of reflecting projected images as well as allowing the user to see through. The modern development

in the area has made the functionality of interacting with objects also possible through OHMD. OHMD goes hand in hand with "Augmented Reality" to display add on information along with the real world information on the display screen of the device. The concept of Head Mounted Display has been well defined in [5] and [6].

What is Optical Head Mounted Display?

Optical Head Mounted Display or in the context of this paper "Optical See-through Head Mounted Display" is a type of wearable computer [7]. As is it is clear with the name; Wearable Computers are devices which users wear and use them as part of daily routine. In such environments, computers provide information that is appropriate to the users' situation that is collected by using sensors worn on the users. One famous examples for wearable computing systems have been developed in [8]. It is a navigation system for tourists giving them required information about places and directions.

A head mounted display is generally worn on eyes as an eye-gear or glasses. The optical see-through HMD shows information without interfering with the user's view of his/her surroundings.

What is Augmented Reality?

Augmented Reality (AR) is the augmentation or superimposing of elements by computer generated sensory such as video, GPS data or graphics over the real world environment. It can be understood more precisely by a concept called mediated reality in which artificial information can be add or subtract or manipulate or overlaid on the real world.

With the help of advanced AR technology, information about the real world becomes interactive and manipulable to/by the user [9], [10].

Augmented Reality in Head Mounted Display

Augmented Reality in itself is a wide area of study. It is a growing technology which is focused on minimizing the difference between real and virtual by giving the user the information he/she needs on the place where the information is needed. So is Head Mounted Display. HMD or OHMD is a very broad area of research and work. The development on glasses that can be used as entertainment devices has been done by researchers since early 2000s and late 1990s. There are many devices available in consumer-market that can be used as entertainment devices. These

are used to display video on glass, show virtual reality and animations on glass. Such are Vuzix M100 [11] and Vuzix WRAP 1200 DX [12].

There is a small and relatively very new and developing phase of technology that lies between the overlapping region of OHMD and AR. Use of Augmented Reality in OHMD is in its very initial stage and there are very few researchers, developers and organizations working in this field. The use of AR in OHMD devices open up great opportunities both for developers and users. In this area, AR powers the display of OHMD. The user views through the lens and sees a natural real world as he would through normal glasses but AR accompanies this real world view with some useful information based on what user is viewing. Two example scenarios are given below.

Example 1. There is a wide scope of AR based OHMD in the field of surgery. An idea of a glass is proposed which is specifically designed for surgeons. Surgeon views through the glasses and sees a normal operation scenario where some organ of patient is defected. The AR in the glasses now displays useful information on the glass such as current stage of organ, medication process needed, and faulty parts of organ based scanning done by the glass itself.

Example 2. Consider another example in sports. An idea is proposed to help a fielder in a game of cricket through AR based glasses. In a match of cricket, the captain is wearing AR based glasses and watches the batsman on strike through it. The AR computing method on glass scan the player and displays the information such as strong areas of that batsman, his favorite strokes and the captain can arrange the field based on these information.

III. CURRENT WORKS

A. Meta Spaceglasses:

Meta is a pioneer in AR based HMD development. Meta is located in California, USA and have developed device called MetaPro also commercially known as Spaceglasses which can easily be called the most advanced AR based glasses. MetaPro feature essential components as IMU, cameras, lenses and display along with a fully featured pocket computers that powers the glasses [13]. The glass unit is connected with the computer through a wire. The pocket computer has following specifications:

- Intel i5 CPU

- 4 GB RAM
- 128 GB SSD
- WiFi 802.11n
- Bluetooth 4.0
- 32WHr battery

MetaPro glasses have two 1280x720 pixel LCD displays each with 40 degrees field of view. MetaPro glasses will be used to control real-world objects using hand gestures in 3D. The hands will be recognized by glasses and the motion will be tracked by IMU and recorded. The glass then control the field of view of user and renders the augmented reality content onto the display of glass [14].

Meta also develops apps to be used with the glasses. These apps range from various games, camera apps and industrial design apps. So far they have around 500 apps in their catalogue [15]. The glasses can be used for variety of things such as normal tasks performed by smartphones to advanced tasks of creating industrial designs and getting integrated with the 3D printer and printing new objects.

Meta also provides with a bunch of software such as Chess, 3DSculpt+Print tool, Laser Tag, Voxel Editor, MetaCraft (a MineCraft simulator).

Developers can develop apps for MetaPro glasses using Unity based SDK for development. Steve Mann, the father of wearable computing is the lead scientist of MetaPro project.

B. The Technology Partnership (TTP):

TTP is Europe's technology and development company established in 1987. TTP's Augmented Reality department led by Dr. Roger Clarke has created an effective Head mounted Augmented Reality display.

It is a conventional glass, transparent, curved lenses and gives a clear field of view to the user. It has a projector mounted at the temple arm of the glass. The projector sends the image to the center of the lens which then beams the image back into the user's eye. TTP uses LED based optics and completely transparent curved lenses hence overcoming the issues like dark lens, huge frames and partially or totally obscured field of view.

The mounted projector projects the light to the lens. The lens contains an embedded structure that redirects the light to user's eye. The lens also compensates the astigmatism. The structure is also coated with slightly reflective neutral layer. This structure is then sandwiched in lens by same refractive index material [16]. TTP has also invented a very high speed switchable fast focus lens technology that can be used to create a true 3D experience. The field of view for the AR display can be varied, while TTP's very high speed Switchable Fast Focus lens technology (SwiFT) can switch the focal length of the lens at up to 1kHz so that different multiple focal plans in a scene can be displayed simultaneously, resulting in a true 3D experience.

TTP don't use the pupil tracking approach as used in many other HMD. Instead, electrodes are mounted at the temple arm which measures the eye movements in the muscles there. Electrical signals in those muscles can be used to determine in which direction the user is looking. The users don't have to do anything in the whole process. The headset can show a monochrome 640 x 480 image. The end result is digital picture overlaid over the real world[17].

While TTP believes its new technology offers hands-free augmented reality for leisure and consumer applications such as ski goggles, running or cycling glasses and interactive gaming, it is also exploring uses in military, emergency services, logistics and manufacturing environments.

C. Atheer Labs:

Atheer Labs' One glasses are HMD devices running on android operating system. One Glasses follow the minimalistic design approach and are compact n size and shape. The devices is still in its development phase and only prototypes have been shown to the general public. The main technical specifications of device are

- 65º field of view
- 8MP camera
- 1024x768 display on lenses
- Connection to android device [18]

Atheer Labs have also planned to give these glasses to Developers who can build 3D gestures based apps for this device. This special developer kits also have a small pocket computer running on Snapdragon 800 CPU and also has HDMI & USB ports [19].

Atheer Labs' glasses take input from hand gestures in 3D environment and based on the input from hand show an augmented video stream on the glass display giving the user a full in-depth immersive view. These glasses are a complete see-through display which gives the users the feeling of seeing the interaction in the foreground of real world information making the concept of augmented reality a reality here. The device at this moment can perform various tasks of interacting with real world objects [20].

There is a low power consuming gesture detection software on glasses which catches the gestures made by hand and transfers them to host device. The devices also takes input using Natural Language Processing and computation is done by android operating system on host device. The device runs around 800000 android apps in 2D but real-time 3D gesture based apps are not in large numbers.

Atheer SDK is an android APIs based software development kit which will enable developers to create 3D apps. The SDK is available as an extension to Unity 3D and Vuforia SDK.

D. Innovega:

Most HMD positions their tiny image display as a "glance-able" data display (Google glass)[21]. But Innovega has come out with the solution for delivering the large image overlay without any blur vision to the user. Clearly we cannot focus on something large that is 5 cm from our eyes.Innovega eyewear system is made up of two parts: glasses and contact lenses[22]. The contact lenses give you enhanced focusing abilities, so you can see near and far at levels beyond what the normal eye can see

The lens has three main components, two filters and lenslet.

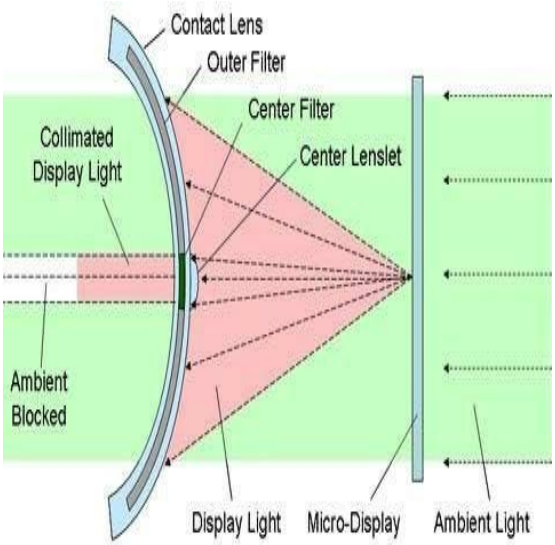
Filters: Their job is to block out very narrow bands of red, green and blue light. The filters are present inside the lens. One is the Outer filter and one is the center filter just behind the lenslet.[23]

Lenslet: It focuses the light on our eyes for the clear vision of display.[23]

Functioning:

The RGB display used by innovega emits the bands of light. These light are blocked by the filter.The only part of lens that isn't covered by the display blocking filter is the center which is a tiny lens. The light blocking filter makes sure that you can see normally while making the

display invisible. The lenslet refocuses the light coming in from the display so that you can see it even though it is closed, while a filter behind the lenslet blocks all wavelengths of light except for three narrow bands emitted by the display to keep user from getting blurry spot.[24]



We can blend the contact lens and glasses technology into one solution but there are limitations. It creates a tiny field of view.

IV. FUTURE ASPECTS AND LIMITATIONS

Although OHMD technologies are advanced but we cannot deny the fact that they are just in their starting phase. This is a new emerging field and many large organizations have noticed that it will play a huge role in the future IT industry. Information is most valuable thing and everyone wants easy access to every kind of information required at instance. OHMD can provide any desired information at just user's hint. On the other hand, limitations of HMDs cannot be neglected. Database limitation is one of the major concern i.e an OHMD can only provide information which is available in its database.

V. CONCLUSIONS

Since 1960s the HMD designs have taken many forms. Many applications from medical, education to day to day use have emerged that are driving new concepts for HMDs across multiple tasks up to near field visualization. Today there are many limitations in HMDs and we

cannot yet enjoy the Augmentation to its fullest. But we can say that in coming 5-10 years AR based HMDs will be on its peak and would be applicable in all applications. New designs and emerging technologies allow us to design yet more and more advanced HMDs year by year. In this paper we have described how new technologies are coming up and removing the restrictions which were once considered impossible. It is only beginning. An exciting era of new technologies is about to emerge driven by mobile wearable displays as it applies to our daily lives in the same way mobile phones are.

VI. ACKNOWLEDGMENT

We would like to thanks proof- readers, honourable teachers,fellow student, and supportive friends.

VII. REFERENCES

[1] Rolland, J.P.; Fuchs, H. Optical versus video see-through head-mounted displays. In wearable compures and augmented reality; Caudell, T., Barfielf, W., Eds.; Erlbaum, 2001.

[2] Sutherland, I.E. A head-mounted three-dimensional display. Fall Joint Comput. Conf. AFIPS Conf. Proc. 1968, 33 , 757-764.

[3] Head Mounted Displays; Melzer, J.E., Moffit, K., Eds.; McGraw-Hill: New York, 1997.

[4] Helmet-Mounted Displays: Design Issue for Rotary-Wing Aircraft; Rash, C.E., Ed.; SPIE Press PM : Bellingham, 2001.

[5] Qianying Wang, Dayuan Yan, Dongdong Weng and Zeyong Qi. 2011. EVALUATION OF HUMAN-COMPUTER INTERFACE FOR OPTICALSEE-THROUGH AUGMENTED REALITY SYSTEM. Association for Computing Machinery, Inc.

[6] Tanaka K., Kishino Y., Miyamae M., Terada T., and Nishio S. 2008. An Information Layout Method for an Optical See-through Head MountedDisplay Focusing on the Viewability. IEEE International Symposium on Mixed and Augmented Reality 2008

[7] Mann, Steve (2013): Wearable Computing. In: Soegaard, Mads and Dam, Rikke Friis (eds.). "The Encyclopedia of Human-Computer Interaction, 2nd Ed.". Aarhus, Denmark: The Interaction Design

Foundation. Available online at http://www.interaction-design.org/encyclopedia/wearable_computing.html

[8] M. Kanbara and et al. Nara palace site navigator: A wearable tourguide system based on augmented reality. In Proc. 3rd CREST/ISWCWorkshop on Advanced Computing and Communicating Techniques forWearable Information Playing, pages 7–14, 2004.

[9] Ganapati, Priya.2009. "How it Works: Augmented Reality." Wired.http://www.wired.com/gadgetlab/2009/08/total-immersion/

[10] R. Azuma. 1997.A survey of augmented reality. ACM SIGGRAPH, 1-38

[11] Vuzix M100 Smart Glass http://www.vuzix.com/consumer/products_m100/

[12] Vuzix WRAP1200 DX Video Glass http://www.vuzix.com/consumer/products_wrap_1200dx/

[13] Lawler R. 2013. TechCrunch http://techcrunch.com/2013/12/17/meta-pro/

[14] Gorman M. 2013. Engadget http://www.engadget.com/2013/12/17/meta-pro-smart-glasses/

[15] Ramirez E. 2013. Wall Street Journal. http://live.wsj.com/video/augmented-reality-seen-through-meta-glasses/7B67CF88-CF9C-46E1-8F97-856BAB8548B4.html#!7B67CF88-CF9C-46E1-8F97-856BAB8548B4

[16] Chris Davies. September 2012

http://www.slashgear.com/ttp-augmented-reality-glasses-prototype-takes-on-google-glass-10246668/

[17] Charles Arthur - 10 September 2012

http://theguardian.com

[18] Kelly S.M. 2013. Mashable

http://mashable.com/2013/12/19/atheer-google-glass-competitor/

[19] Gorman M 2013 Engadget http://www.engadget.com/2013/12/19/atheer-labs-smart-glasses/

[20] Velazco C 2013 TechCrunch http://techcrunch.com/2013/12/19/atheer-labs-turns-to-crowdfunding-to-bring-its-3d-augmented-reality-glasses-to-life/

[21]http://www.geekwire.com/2013/google-startup-making-interactive-glasses-augmented-reality/

[22]http://mashable.com/2014/01/08/smart-contact-lenses/

[23]http://innovega-inc.com/new-architecture.php

[24]http://spectrum.ieee.org/tech-talk/consumer-electronics/audiovideo/innovega-delivers-the-wearable-displays-that-science-fiction-promised